

by bacterial action. Accordingly by the double sedimentation an average of more than 60 per cent. of the suspended solid matter or "sludge," which was present in the raw screened sewage, has been caused to disappear. This implies a very considerable diminution of cost in sludge removal and disposal; but it secures the further advantage that the still impure liquid flowing from the settling tanks has become admirably adapted for undergoing adequate purification in the bacterial coke-beds. It is noteworthy that the full power of disposing of sludge is only developed in the sludge after it has remained in contact with the flowing sewage for some considerable length of time; and it is only stale sludge which is efficient in resolving the solid insoluble matter into soluble and gaseous forms. This delay is due to the necessity of cultivating in the sludge the necessary species of bacteria, which are derived from the sewage itself.

The most efficient and rapid method of dealing with the impure liquid, which flows from the settling or so-called "septic" tanks, has been found to consist in treating it intermittently in coke-beds, which have been primed with bacteria by being placed for some weeks frequently in contact with sewage. The complete cycle of treatment in the London beds consists in filling the coke-bed, emptying it after a couple of hours, and then leaving its coke contents in contact with the interstitial air for another period of two hours. It has been found possible to repeat this cycle four times in twenty-four hours, and using beds six feet in depth to purify the settled sewage at the rate of two million gallons per acre per twenty-four hours. By this purification an effluent is obtained which is saturated with dissolved oxygen, which remains entirely inoffensive in smell for an indefinite period in an incubator at summer heat, and which, therefore, when discharged into a water-course would maintain the respiration of fish and would never render the water offensive.

Chemical examination shows that the treatment in the coke-bed has reduced the readily oxidisable dissolved matter in the settled sewage by from 60 to 70 per cent., and the whole oxidisable matter in the unsettled raw sewage by more than 90 per cent.

Bacteriological examination indicates that the effluent contains large numbers of bacteria; but the presence of these bacteria is useful in effecting inoffensively the removal of the organic substances, which still remain in the effluent, as soon as the effluent mingles with the well-aerated river water.

It is noteworthy that the sewage capacity of a newly-made coke-bed progressively decreases for a time, while its purifying power is being developed by contact with settled sewage. But the capacity ultimately becomes equal to about 30 per cent. of the whole cubic space which has been charged with coke; and, if the treatment is carried out regularly under proper supervision, this capacity fluctuates by only a few units per cent. above and below this final capacity throughout the period of many years during which the bed has as yet been worked.

The decrease of capacity to 30 per cent. is the so-called "choking" of the bed. It is due to a bacterial jelly-like growth of bacteria and zoogloea upon the coke-surfaces. If this jelly is removed and exposed to air over

mercury, it will rapidly absorb oxygen from the air, and will therefore produce a partial vacuum. It appears that this growth is actually charged with oxygen during the aeration or resting of the coke-beds between the chargings with sewage liquid. The growth upon the coke-surfaces, which reduces the capacity of the bed, appears, therefore, to be the essential element of successful purification.

It is noteworthy that the growth may be unduly developed, with corresponding decrease in the sewage capacity of the bed, by over-frequently filling the bed; and by resting the bed, or reducing the number of fillings, the growth may be diminished and the capacity of the bed correspondingly increased. A great increase in the development of the jelly involves increased purification, but reduction in the amount of sewage dealt with, and *vice versa*. Accordingly a working rate which is most advantageous on all grounds must be arrived at by trial and experience.

Careful examination of the composition of the interstitial air, even at the bottom of a coke-bed thirteen feet in depth, proves that the air is not deficient in oxygen to an extent greater than 25 per cent. of that normally present in fresh air. It appears, therefore, that although oxygen is being rapidly absorbed during the resting or aeration of the bed, the oxygen which is absorbed is rapidly replaced by natural diffusion, and mechanical aeration of the bed is unnecessary.

It has been proved that the chemical refuse which is found in the sewage of manufacturing towns seldom exerts any prejudicial action on the action of the bacteria or upon the coke-beds. In some towns, however, a preliminary treatment of the sewage has been adopted in order to remove special chemical refuse when it is present in very large quantity. This is not the case either in London or in Manchester.

One hears occasionally of so-called failures in securing bacterial purification of sewage. It is not too much to say that such failures have been due to the improper construction or working of the bacteria beds. Apparently we have still to learn of want of success when an intelligent attempt has been made under competent and experienced direction.

Although the process of natural purification of sewage must eventually become general, its adoption will undoubtedly be delayed by the lack of knowledge on the part of the majority of our public bodies and even on the part of some of their advisers. Those who wish to see the satisfactory results of experimental inquiry usefully and advantageously applied on the large scale will accordingly welcome the appearance and success of such treatises as the one which has suggested the present review.

FRANK CLOWES.

FIFTY YEARS OF BIOLOGICAL STUDY IN AUSTRIA.

Botanik und Zoologie in Oesterreich in den Jahren 1850 bis 1900. Festschrift v.d.K.K. Zoologisch-Botanischen Gesellschaft in Wien. Pp. x+620; with 38 plates and 9 cuts. (Vienna: Alfred Holder, 1901.)

THIS magnificent work illustrates in every way the jubilee of the K.K. Zoological and Botanical Society of Vienna. Twenty-two authors have collabor-

ated in its production ; and its contents are as follows :— (A) A short preliminary history of the Society. (B) A descriptive history of the institutes and corporations dealing with zoology and botany, including horticulture and agriculture. (C) A history of botany in Austria during the fifty years, under the three headings of (a) phytogeography ; (b) morphology, ontogeny, and systematics of cryptogams ; (c) morphology, ontogeny, and systematics of phanerogams ; (d) anatomy and physiology of plants.

(D) A history of zoology in Austria during the last half-century : (1) morphology and systematics, including bionomics and zoogeography ; this enormous range is treated in monographs of unequal compass—Protozoa, Cœlenterata, Echinoderms and Worms are the subject of one, Tunicates and Molluscs of another, Molluscoidea of a third, while the classes of Vertebrata and Arthropods, and the orders of insects among the latter, receive distinct consideration ; (2) a separate article deals with animal morphology and physiology.

A bibliography of the introductory discourses ("Wrogrammaufsätze") of the educational establishments closes the text. The plates are all well-executed lithographs of (deceased) workers at our sciences, and the cuts are for the most part full-page illustrations of biological institutions. Separate indexes of singular completeness are appended, and greatly enhance the value of the book as a work of reference. Unfortunately, in the nominal index no special reference is given to the pages on which the short biographical sketches are to be found, which, as in the case of Claus and Wiesner, for example, may rise to the dignity of scientific biographies.

Thus the work contains a singularly complete record of the work done in natural history in the Empire-Kingdom practically since its inception in the forties of the late century ; for previous to 1845 there existed only agricultural, horticultural and medical societies, which dealt incidentally with nature study. In that year a union of "Freunde der Naturwissenschaften" was founded in Vienna. A year later was the Vienna Academy of the Sciences founded, by the exertions of Prince Metternich, a name associated in other domains with reactionary obscurantism. The modest union formed by Haidinger, which met in the Botanic Gardens, worked quietly on, independently, through the troublous times of '48-'50 ; but in 1850 the primary intention of converting the occasional publication of *Mittheilungen* into a regular *Zeitschrift* developed into the formation of a Zoological and Botanical Society, leaving the geological sciences to the Reichsanstalt. George Frauenfeld, the zoologist, was the founder of the movement, and the first secretary of the Society, which attracted all workers at the study of organisms living and extinct. As in England at that time the biological sciences were largely cultivated by amateurs of the highest birth and rank, so did the young Austrian society gain aristocratic support from the beginning. The first president was Prince Richard zu Khevenhüller Metzch, the second Prince Colloredo Mannsfeld, and we read of the latter that "few were the board meetings from which his Serene Highness was absent." In a country where one-half the population is illiterate, we can understand that education in the highest sense must assume an aristocratic tinge, and the noble

particle "von" recurs frequently among the workers whose names are cited. This much we gather from the short history of the Society, related by Dr. Brunner v. Wattenwyl.

In the histories of botany and zoology, those of phytogeography and zoogeography hold the first places. One of the first objects set before the Vienna society at its foundation was the study of the native organisms of the Fatherland, and many of the provincial bodies have devoted their chief energies to this pursuit. When the faunistic and floristic studies of Austrian travellers are added, we can but admire the wonderful and successful work of a country usually held to be rather behind the average advancement of Europe.

But to say this gives no adequate account of the activity of Austrian biologists. In botany, over against such systematists as Endlicher, Fenzl and Engler may be set Unger, the discoverer of cilia in the lower plants ; Ingen Housz, one of the fathers of plant physiology ; Wiesner and Leitzeb, the histologists and physiologists ; Kerner v. Marilaun, whose grasp of plant-bionomics was of the strongest and widest ; and Čelakowsky, with his unrivalled knowledge of the morphology of flowering plants and their "monstrosities."

When we turn to the history of zoology we find a similar catholic productivity. Unfortunately, the matter is much more scattered, as we have seen in our survey of the contents of the book. Austrian zoologists, indeed, occupy a commanding position : we need but note C. Claus, systematist and morphologist, whose epoch-making works on the Crustacea and brilliant studies on the Cœlenterates were perhaps second in importance to his stimulating powers as an exponent and teacher ; and v. Stein, who practically laid the foundations of our knowledge of the Flagellates. But in every section of zoology Austrians have distinguished themselves, and one of them, F. Eilhard Schulze, is the professor at Berlin.

If we ask ourselves the causes of the extraordinary scientific fertility of a union of countries numbering in all fewer inhabitants than Great Britain, and half of them illiterate for the greater part of the last half-century, the first that presents itself is probably provincial patriotism : each country is anxious that its own possessions shall be duly recognised ; and no one can doubt the efficiency of such a stimulus to the capable student of nature. But the desire is useless without the power to accomplish. We can only find this in the encouragement given to children in Central Europe in the study of systematic and descriptive natural history, and especially that of the local flora. This teaches system, careful observation, accurate detailed description and record—a combination of acquirements realised in none of the disciplines in our own school use. Such work may commend itself as essentially "heuristic" to our enthusiastic band of reformers of school programmes. Moreover, it *does not* involve the direct teaching of philosophical ideas, but recently acquired by the pioneers of science and unintelligible to the young mind, which is, on the other hand, trained not to shirk the irksome accumulation of facts : indeed, the results will depend largely on the work of the scholar himself, and not on his passive reception of the teacher's ideas.

Haeckel has, we know, spoken disparagingly enough of mere systematism, and compared it to "postage-stamp-ology" (the word "philately" had not then been invented). But we read in the dedication of the "Generelle Morphologie" to Gegenbauer how, as a boy of twelve, he had collected a herbarium of local plants with a set of intermediate forms between the "critical species," and already had been led thereby to doubt the orthodox view of the constancy of species; we know his masterly unravelling and grouping of the appalling wealth of forms in the Radiolaria. De Bary once said to the writer: "Without a good systematic knowledge to begin with, no botanist can tell where he is, nor what he is dealing with." Charles Darwin began as a collector, and monographed the *Cirripedia*, and Alfred Russel Wallace was a collecting naturalist. If we want to place ourselves on a par with Austrian and German biologists we must reform our teaching of botany on the common-sense lines followed so successfully abroad, and once introduced by Henslow into the primary teaching of his village school in East-Anglia. As a preliminary to the morphology and bionomics of our academic programmes, there must be laid a sound foundation in the knowledge of organic external form and variety. And so the scientific training of the individual will be pursued on lines corresponding to the acquirement of scientific knowledge by the race, a course which should, at least in this case, commend itself to all educational reformers.

M. H.

GEOGRAPHICAL DISCOVERY.

L'Epoca delle grandi Scoperte geografiche. Di Carlo Errera. Con 21 carte, &c. Pp. xvi + 432 (text, 357). (Milano: Hoepli, 1901.) Price L.6.50.

THIS useful, brightly-written and well-illustrated summary of the geographical progress of Christendom, from the beginning of the Middle Ages, is divided into twelve parts, of which the first eight deal with the pre-Columbian time and the last four with the great age of discovery, from Columbus to Magellan. Among the twenty illustrations are four reproductions of early mediæval maps, from Miller and Beazley, one of Carignano's Portolano of 1300, one of Fra Mauro's map of 1459, one of a section of Juan de la Cosa's chart of 1500, one of the Strassburg Ptolemy of 1513, and one of the 1529 mappe-monde of Diego Ribero. Most of the latter are reproduced from Ruge's "Geschichte des Zeitalters der Entdeckungen." In its text the present work is also mainly based, for its later chapters, upon the same and other works of Ruge's, as well as upon Kretschmer's "Entdeckung Amerikas," Nordenkjöld's "Facsimile Atlas," Harrisse's "Christophe Colomb" and other studies, and Günther's "Zeitalter der Entdeckungen"; for its earlier upon Nordenkjöld's "Periplus," Hughes' "Storia della Geografia," Heyd's "Commerce du Levant," Uzielli and Amat's "Studi biografici . . . sulla Storia della Geografia," K. Miller's "Mappæmundi," Beazley's "Dawn of Modern Geography," Avezac's edition of, and introduction to, Carpini, Yule's Marco Polo, &c.

But although essentially a compilation from more extensive and specialised studies on the history of exploration, Prof. Errera's contribution to the "Collezione Storica Villari" has great merits. It describes with excellent

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lucidity, compression, and good sense the chief epochs in the great drama of European awakening to a fuller knowledge of the world. No attempt, indeed, is made to treat (except allusively) of Arab or Chinese exploration and geographical study; and it might be said that a somewhat fuller appreciation of the latter is almost indispensable for a complete understanding of the European advance to which Prof. Errera restricts himself. It might also be objected that a chapter on the exploration of the north (No. vii. "La Conoscenza del Settentrione"), including the description of the Scandinavian voyages to Iceland, Greenland and Vinland, should precede, and not follow, chapters (iv.-vi.) on the growing knowledge of Asia among Europeans during the thirteenth, fourteenth, and fifteenth centuries.

Once again, more attention might have been given to the career and first voyage (1497) of Giovanni Caboto; and, to instance a very small point, Konrad Miller's "Ebstorfkarte" is not separate from his "Mappæmundi: Die ältesten Weltkarten," but heft v. of the same. But little fault, as a whole, can be found with the way in which the author brings out, section by section, his epitome of what he defines, in his preface, as the "progressive extension of the knowledge of the superficies of our planet," down to the era of the first voyage round the world.

A special word of thanks is due to the excellent critical judgment with which the difficult voyages of the Zeni are handled—a subject hard enough in itself and doubly hard for a fellow-countryman of Nicolo and Antonio Zeni. Italians, perhaps, did more than any other people—more even than Scandinavians and Portuguese—for the advance of European trade and exploration, as well as for the perfecting of geographical science; from Antoninus of Placentia to Marco Polo and Ludovico Varthema, from Malocello and the Vivaldi to Columbus, Verrazano and the Cabots, from Flavio Gioja to Fra Mauro and Toscanelli, Italian travellers, merchants, and men of science bore a foremost share in the work of opening up the world. Among the early Portolani, the first true maps ever set forth, an overwhelming preponderance (413 out of 498) are Italian; and the whole of modern trade, with all the possibilities of civilising progress which it contains, might almost be called a discovery of Italian genius. Italian scholars of the present day may, therefore, be said to have a special claim upon the subject here discussed, as the subject has a special claim upon them; and although this *breve storia* has not the original value of Marinelli's remarkable study on the geography of the Dark Ages, it deserves a most cordial welcome.

OUR BOOK SHELF.

Die Tierwelt der Schweiz in ihren Beziehungen zur Eiszeit. Von Prof. Dr. F. Zschokke. Pp. 71. (Basel: B. Schwabe, 1901.) Price Mk. 1.20.

HERE in short compass we have set forth the relation of the flora and especially of the fauna of Switzerland to the Glacial period. Geologists have been wont to cite the occurrence of Arctic plants in the Alps and the mountains of middle Europe as strongly confirming their belief in the former prevalence of a glacial climate in what are now temperate latitudes. In his present work the author shows that, however cogent that evidence may be, it is in no degree stronger than that derived from a